PATENT SPECIFICATION

(11) 1 503 136

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(21) Application No. 31890/76 (22) Filed 30 July 1976
(31) Convention Application No. 601682
(32) Filed 1 Aug. 1975 in
(33) United States of America (US)
(44) Complete Specification published 8 March 1978
(51) INT CL² H01L 23/30
(52) Index at acceptance
H1K 11A3 11D 11Y 1CX 1D3A 2S20 4C11 5A1 5A4 5A 5B1 5H2 5P6 5PY 5T PG

(19)

(54) SEMICONDUCTOR DEVICE ASSEMBLY

(71) We, OWENS-ILLINOIS, INC., a Corporation organised and existing under the laws of the State of Ohio, United States of America, of Toledo, State of Ohio, United States of America, (assignee of CHARLES FREDERICK RAPP and PAUL LAWRENCE WHITE), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to a semiconductor device assembly for use in electronic circuit applications. More particularly, this invention relates to a semiconductor device assembly comprising a read-only-memory device (i.e. ROM) which is electronically programmed to perform a specified logic function. ROMs are repositories for unchanging information such as control sequences for data processing units, tables of constants, translators between codes and the like. Occasionally ROMs store programs similar to those usually kept in the main memory but which are never purposely altered. Once the ROM is programmed with the desired logic function, it is protected from accidental alteration.

In manufacturing ROMs, it is often necessary to reprogram the memory circuit several times to achieve the precise logic function for the application at hand. Such programming applications are accomplished by electronically addressing the circuit and then erasing the improper circuit logic by exposure to ultraviolet radiation. Such techniques are known in the art (see the article entitled "Programmable ROM" by Gerald Luecke, Jack P. Mize, and William N. Carr, Texas Instrument, Electronic Series, McGraw-Hill 1973 pp. 168—173) and form no part of the present invention.

To program the ROM, electrical programming pulses are applied to the memory circuit element to store data bits as charges in storage cells. To make the ROM erasable, the chamber containing the circuit element has a window which is transparent to ultraviolet radiation. This allows the programmer to expose the circuit element to a high intensity short wave ultraviolet radiation, which will erase the data in a matter of minutes.

Such ROM devices are well known in the art as disclosed in the articles "Programmable ROM" by Gerald Luecke, Jack P. Mize, and William N. Carr, Texas Instruments, Electronic Series, McGraw-Hill (1973) pp. 168—173; "Densest Erasable ROM has 8-k Bits" by Bernard Cole, Electronics (April 3, 1975) p. 117; "What Are These Things Called ROMs?" by J. J. McDowell, Electronics in Industry, (March 1975) pp. 16—20; and the articles in Electronics (August 2, 1973): "Down Memory Lane" p. 77; "Addressing and Transfer" p. 77; "Three Read-only Variations" p. 79; and the Special Report, p. 80.

To accomplish these results in the past, it has been the practice to construct the lead frame assembly for the ROM device with a quartz window. While quartz windows have been suitable for many applications, serious manufacturing problems have arisen in achieving a stress-free, seal between the quartz window (having a coefficient of thermal expansion of about $5\times10^{-7}/°C$ (0—300°C) and the ceramic support which is usually an electronic grade of alumina having a coefficient of thermal expansion in the range of about $50—90\times10^{-7}/°C$ (0—300°C) depending on the type and nature of the alumina. Accordingly stress cracks and other mechanical defects and failures often develop in the seal under conditions of service at changing ambient temperatures. Once the seal cracks or fails, moisture from the ambient can contact the memory circuit element and the device becomes unsuited for further use.

Another disadvantage of quartz is that quartz windows of optical quality and appropriate geometry are not easily manufactured due to the refractory nature of quartz.

According to the present invention there is provided a semiconductor device assembly comprising an electrically insulating ceramic support having a cavity, an electronically programmable memory circuit element positioned in said cavity, said circuit element being re-

sponsive to ultraviolet radiation to the extent that any program stored in said element is erased upon exposure to intense ultraviolet radiation, electrical addressing circuitry carried by said support and connected to said circuit element, and an ultraviolet radiation transmissive window sealed in a position overlaying said cavity; said window comprising a homogeneous, soda-lime-silica glass having an ultraviolet transmission of at least about 30% at 2500 Å and comprising:

Component	Weight %
SiO_2	65 to 75
CaO	5 to 15
Na_2O	5 to 15

The window of the semiconductor device assembly of the present invention is preferably transparent to radition in the wavelength of from 2250 and 3500 angstroms and may be readily manufactured and readily sealable to a ceramic lead frame support.

In addition to the foregoing components, the overall glass composition can contain up to about 20% of other glass making oxides to adjust the thermal expansion characteristics or forming properties of the glass. Such oxides include 0—10% Al_2O_3, 0—12% B_2O_3, 0—10% MgO, 0—10% BaO, 0—10% P_2O_5, 0—10% ZnO, 0—10% Li_2O, and 0—5% ZrO_2 that do not materially increase the ultraviolet absorption of the glass. It is understood, of course, that these ranges are based on 100% total composition.

Refining agents such as antimony oxide, arsenic oxide or the like can be present in small proportions (e.g. up to about 1/2 to 1% by weight) if such ingredients are deemed necessary for glass refining. As a general consideration, oxides which tend to increase absorption in the ultraviolet region should be avoided.

The above compositions have a coefficient of thermal expansion in the range of 65 to $90\times10^{-7}/°C$ (0—300°C) which can be tailored by adjusting the ratios and proportions of components to approximate the coefficient of thermal expansion of the material (e.g. the ceramic support) to which it is to be sealed. More importantly thin windows (e.g. 20 to 100 mil thickness) of these compositions transmit 30% and preferably 50% of the incident radiation at 2500 Å. This is a significant proportion because it has been established that efficient erasure of the memory circuit element is achieved by using windows having these characteristics with an ultraviolet source emitting radiation at a dominant wavelength of 2500 Å.

Oxides which should be minimized and preferably absent are iron, titanium, uranium, germanium, copper, silver, gold, vanadium, tantalum, chromium, tungsten, platinum, bismuth, lead, and other rare earths and transition metals which absorb ultraviolet. In that iron and titanium are commonly glass batch impurities, batch materials should be selected so that the final window glass composition has a combined iron oxide and titanium oxide concentration of less than about 100 ppm.

It is not necessary for the windows to be transmissive in the visible range (i.e. 4000 Å—7000 Å) as long as the transmission is at least about 30% at 2500 Å. In this regard the window can be visually transparent, translucent or opaque and in some instance can appear to be colored. Certain oxides such as cobalt oxide and nickel oxide can improve the transmission in the ultraviolet region by converting iron present to the Fe^{++} state which absorbs less ultraviolet radiation than the Fe^{+++} state. [See the text entitled, "Coloured Glasses" by W. A. Weyl, Dawson's of London (1959).] and cobalt oxide and/or nickel oxide may therefore be present in the window glass composition if desired.

It is appreciated that ultraviolet transmissive glasses have been prepared in the past as in U.S. Patents 2,719,932; 3,150,281; 2,561,325; 2,895,839; 2,001,504; 1,971,309; 1,964,321; 2,116,742; 2,152,988; 2,152,994; 2,177,728; 2,200,958; 2,212,879; 1,779,176; 2,272,992; 1,774,854; 2,693,422; 1,830,904; 2,505,001; 2,087,762; 2,423,128; 2,100,391; 3,677,778; 3,671,380; 2,569,793; 2,757,305; 2,240,327; 2,433,928; 2,056,627; 2,031,958; 2,077,481; 1,886,280; 2,107,935; 3,496,401; 2,398,530; 2,382,056; 1,830,903; 2,904,713; and 1,830,902; although none of these patents disclose or suggest the specific and unusual advantages achieved by the use of the soda-lime-silica window in the lead frame structure of invention.

The invention will now be further described by way of example with reference to the accompanying drawings wherein Figs. 1 and 2 are exploded, perspective views of embodiments of semiconductor devices of the present invention.

Referring now to the drawings reference numeral 10 indicates an electrically insulating ceramic support which can be silica, zirconia, beryllia, or alumina although alumina is preferred for its low cost and availability in grades suitable for electronic applications.

Such electronic grades of alumina have a coefficient of thermal expansion in the range of 50—$90\times10^{-7}/°C$ (0—300°C) and usually in the range of 60—$70\times10^{-7}/°C$. The overall dimensions of such ceramic supports can vary widely although a length of about 1 inch with a width of 1/2 inch with a thickness of about 1/10 of an inch is typical.

Centrally positioned in support 10 is cavity 10*a*. Cavity 10*a* extends only about 1/2 to 3/4 of the way through the ceramic support to define cavity floor 10*b*. In a typical application, the cavity has a dimension of about

1/4 inch square and is centrally positioned in the ceramic support as shown.

Mounted on the floor 10*b* of cavity 10*a* is the ultraviolet erasable, programmable, memory circuit element 11 constructed of a silicon semiconductor as described in the article entitled "Programmable ROM" discussed above. This circuit element is conventional in the art and forms no part of the present invention per se.

Ceramic support 10 also has embedded therein and passing therethrough a plurality of electrical conductors 12 which are attached to circuit element 11 by means of lead wires 13 as is conventional in the art. Only six conductors are shown for the purpose of illustration, although many more are present in commercial devices. The electrical conductors 12 are for carrying the programming signal and subsequent connection into the computer or other application. Positioned around the edges of cavity 10*a* on ceramic support 10 is sealant layer 15 which can be an inorganic seal such as a lead borate solder glass as disclosed in U.S. Patent 3,778,242 or commonly assigned, U.S. Patent 3,954,486 or an organic seal such as epoxy resin (e.g. the glycidyl ethers of Bisphenol A crosslinked with polyamines as in Chapter 8 of Polymer & Resins by Brage Golding, "Technology of Manufacture: Synthetic Condensation Products" pp. 242—373 (1959) or Chapter 2 of Handbook of Epoxy Resins by Henry Lee and Kris Neville, "Synthesis of Glycidyl-Type Epoxy Resins" pp. 2-1—2-33 (1967)).

As shown in Fig. 1, sealant layer 15 is positioned for sealing ultraviolet transmissive glass window 16 to ceramic support 10 in a position overlaying cavity 10*a*. Window 16 which has length and width dimensions slightly greater than cavity 10*a* so as to overlay the cavity 10*a* as shown by the arrows in Fig. 1. In the embodiment shown in Fig. 1 the sealant layer 15 can be applied as a pattern conforming to the sealing area near the edges of the window 16 for subsequent fusion sealing to ceramic support 10. Alternatively, the sealant layer 15 can be applied as a pattern conforming to the sealing area on the ceramic support for subsequent fusion sealing with the window 16. A thin layer of sealant can also be placed on corresponding surface areas of the window and the ceramic support.

The embodiment shown in Fig. 1 represents the preferred practice of the present invention where the window is sealed directly to the ceramic support with a solder glass seal from the standpoint of mechanical strength and hermeticity.

The embodiment shown in Fig. 2 is similar in construction to the embodiment of Fig. 1 except for the presence of metal gasket 14 interposed between sealant layer 15. Similar parts in Figs. 1 and 2 are identified by the same reference numerals.

As shown in Fig. 2, a metal gasket 14 is to be adhesively secured to the ceramic support 10. Gasket 14 is constructed of gold, silver, kovar ("Kovar" is a registered Trade Mark), or some other inert metal or alloy which is provided for as an intermediate sealing surface for joining the window to the ceramic support. Gasket 14 is optional and in many applications it is not present when the window is sealed directly to the ceramic support with solder glass sealant or other suitable sealant. As shown in the drawing, the optional gasket 14 has an aperture therein which corresponds to the outside dimensions of cavity 10*a* and is aligned in registry therewith.

The metal gasket 14 can also be in the form of a thin layer (e.g. up to a few mils) of an inert metal such as gold or silver which has been deposited on the ceramic support 10 or the glass window 16 by vacuum deposition, screen printing, chemical vapor deposition, or other known techniques.

The composition per se of the lead-borate (inclusive of lead-zinc-borate) solder glass employed forms no part of the present invention and can be a conventional solder glass as disclosed in U.S. Patent 3,778,242 selected or modified to achieve compatible fusion sealing properties. The particle size of the lead-borate solder glass is not particularly critical to the practice of the present invention and any conventional particle size distribution such as shown in U.S. Patent 3,778,242 can be employed. Such lead-borate solder glasses usually have coefficients of thermal contraction of about 80 to $110\times10^{-7}/°C$ over the temperature range from the sealing temperature to room temperature. The coefficients of expansion can be modified by the use of filler to more closely approximate the coefficients of expansion of the window and ceramic support to be sealed. Such glasses are used in forming vitreous seals as well as glass-ceramic or semicrystalline seals as is known in the art and weight % compositional ranges are set forth where the total content of all oxides is 100%.

Oxide	Broad Range	Usual Range
PbO	70—85	75—85
ZnO	0—20	2—16
B_2O_3	5—15	8—15
SiO_2	0—10	0—5
BaO	0—3	0—2
SnO_2	0—5	0—2

Other conventional glassmaking oxides such as CaO, CuO, Bi_2O_3, Na_2O, K_2O, Li_2O, CdO, and Fe_2O_3 can be included. However, it is preferred in many instances not to employ these ingredients but rather to provide compositions which consist essentially only of those ingredients set forth above. The ultra-

violet transmission characteristic of the solder glass is not a factor.

In some instances refractory fillers are employed to adjust the coefficient of expansion and fusion characteristics. The particulate refractory filler useful in this invention can be any of such well-known materials, synthetic or natural, conventional to the art. These refractory fillers include silica; lithium aluminosilicates including β-spodumene, petalite, β-eucryptite and low expansion lithium aluminosilicate glass-ceramics, as in U.S. Patent 3,788,865, (with or without colorants), alumina; aluminosilicates including mullite clays and other clays; zirconia; tin oxide; and zircon.

The specific weight percents actually employed of particulate solder glass and refractory filler will vary over a wide range depending upon the ultimate application. Generally speaking, a sufficient amount of refractory oxide should be added such that together they provide the necessary coefficient of expansion match-up, flow properties, and crystallization speed to decrease the normal time-temperature factor of the heat-sealing process while at the same time provide a strong, tightly hermetic, moisture-resistant seal. This is usually in the range of 1% to 25% by weight of the solder glass/refractory filler blend with about 5% to about 20% being suitable for most applications.

The seal is formed by thermally fusing a layer of the blend of particulate solder glass and particulate refractory filler while in intimate contact with the window and ceramic support at a temperature and for a time sufficient to flow and fuse such blend into a strong, hermetic seal having a coefficient of thermal contraction less than the solder glass initially present in the blend. Temperatures in the range of 350°C—500°C for time periods ranging from about 1 minute to about 1 hour are typical for crystallizing and non-crystallizing solder glasses with the lower temperatures usually requiring the longer time periods. In the usual practice, strong, hermetically tight, reproducible seals are formed in about 5 minutes to about 30 minutes at temperatures in the range of 350°C to 450°C. The time that the temperature is in excess of 400°C should be held to a minimum because such high temperature can have a detrimental affect on the memory circuit element.

The resulting seal formed from the blends of invention can be vitreous or devitrified (i.e. crystalline) seals depending upon the solder glass composition, and time and temperature of fusion. The lead-borate solder glasses containing zinc have a greater tendency to crystallize during fusion sealing to form devitrified seals. The lead-borate solder glasses containing little or no zinc have a greater tendency to remain vitreous during fusion sealing.

The blends of particulate solder glass and particulate refractory filler for this invention can be applied to the window and/or ceramic support to be sealed by any conventional technique as in U.S. Patent 3,778,242. Examples of such techniques include spraying, screen-printing, and pyrolyzable tapes. In forming the blends into sprayable slurries, they are usually dispersed in a liquid organic vehicle such as alcohol to a sprayable viscosity. Another example of a slurry vehicle is 1-1/2 percent nitrocellulose in amyl acetate or an alpha methyl styrene resin. Any of the conventional paste organic vehicles can be employed for forming a paste while conventional tapes can also be used.

Once the blend is applied, it is dried and/or heated in accordance with conventional techniques to burn off the vehicle and then fired to fuse the seal, with or without crystallization or devitrification. For sealing and glazing an assembly a heat up and cool down rate of about 80°C/minute and higher can be used without causing thermal shock. Such a heat cycle usually insures a high quality seal without causing detrimental thermal stress in workpieces.

Glass window compositions described above can be melted and refined from conventional glass making batch materials to yield compositions within the ranges specified. Such batch materials include sand, limestone, lime, feldspar, and soda ash. The choice of raw material is based on economic considerations although it is often advantageous to use reagent grade chemicals to minimize the content of undesired impurities.

The glass making materials are melted using conventional glass making techniques. Such techniques include melting in gas and electrical fired furnaces at temperatures in the range of 1500° to 1600°C for a time period up to several hours in neutral or reducing atmosphere with or without stirring to achieve homogeneous batch free, seed free compositions. The compositions are then cast, molded, drawn, or otherwise formed into the desired window configuration and ground and polished to achieve the desired degree of surface smoothness.

Neutral or reducing melting atmospheres are preferred over oxidizing atmosphere so that any iron that may be present will be in the ferrous state rather than the ferric state. Oxidizing atmospheres can be used, however.

In this regard, a window size of about 1/2 inch long by 1/2 inch wide with a thickness of about 20—100 mils is suitable for many applications. It will, of course, be understood that the surface smoothness of the window has an influence on the ultraviolet light transmission characteristics with rough surfaces tending to transmit less light due to surface

diffusion. Accordingly, it is preferred that the surface be as smooth as practical and the windows are usually polished with a fine abrasive to achieve the desired surface smoothness. For instance, polishing with a 240 grit silicon carbide abrasive paper produces a surface having an average roughness in the range of 1 to 10 microinches. This roughness value refers to the height of the "peaks" from the "valleys" on the surface. When drawing processes are employed the polishing operation is often not required to achieve the desired surface smoothness.

The Examples that follow will illustrate in detail how to prepare and assemble the device just described. In the Examples that follow all parts are parts by weight, all percentages are weight percentages, and all temperatures are in °C unless stated otherwise. In some instances the reported glass composition do not add up to exactly 100% due to analytical variations.

Example 1

A soda-lime-silica glass having the composition:

Component	Weight %
SiO_2	73.3
Al_2O_3	1.7
Na_2O	13.5
CaO	11.5

is prepared from reagent grade silica, alumina, sodium carbonate, and calcium carbonate by melting and refining in a refractory crucible at a temperature of 1500 to 1600°C for several hours with occasional stirring until a homogeneous batch-free, seed-free, clear glass is formed. The glass is then cast into a small billet and cooled to room temperature. The glass has the following properties:

Liquidus temperature=1013°C
Temperature, where the log of the viscosity in poise is 13.4,=551°C
Fiber softening point temperature=731°C
Density=2.491 g/cc
Coefficient of thermal expansion (0—300°C)=85.9×10^{-7}/°C

Small windows having the dimensions of 1/2 inch by 1/2 inch by about 35 to 40 mils in thickness are cut from the billet with a diamond saw. The surfaces of the window are ground to smoothness with a 240 grit silicon carbide polishing paper to yield a surface "roughness" of about 10 microinches.

The ultraviolet light transmission characteristics of this window and the other windows of the Examples are obtained on a Beckman spectrophotometer and reported in the following tables.

The glass window is sealed to the support using a kovar (Kovar is a registered Trade Mark) metal alloy gasket and an epoxy resin adhesive as shown in Figure 2. The memory element is electronically programmed and erased with ultraviolet radiation in the wavelength of about 2300 to about 3500 angstroms as described above and excellent results are obtained. The ultraviolet lamp employed is a high intensity lamp designed to emit radiation at about 2500 angstroms. Furthermore, the seal is quite rugged and durable.

In another embodiment, a thin layer of metallic gold is screen printed around the surface of a glass window as described above to overlay an area as indicated in the drawing. A device is assembled as above and similar results are obtained.

In another embodiment a glass window produced above is sealed to the kovar (Kovar is a registered Trade Mark) metal alloy gasket using a solder glass seal by the fusion sealing techniques described above. This test shows that solder glass sealing can be used with the kovar (Kovar is a registered Trade Mark) gasket if desired. This is not the usual practice, however.

The resulting assembly is electronically programmed and erased with ultraviolet light as above and similar results are obtained. The seal is quite rugged and durable.

Examples 2—6

To further demonstrate the principles of the present invention the following glass compositions are prepared and formed into windows as described above.

Examples	2	3	4	5	6
Component					
SiO_2	74.3	73.3	73.3	73.3	73.3
Al_2O_3	1.7	1.7	1.7	1.7	1.7
CaO	11.5	11.5	10.5	13.5	12.5
Na_2O	12.5	12.5	12.5	11.5	11.5
B_2O_3	0	1.0	2.0	0	1.0
Coefficient of thermal expansion $\times10^{-7}$ (0—300°C)	81.7	82.8	81.3	80.8	82.3
Temperature °C where log viscosity in poises is 13.4	571°C	572°C	568°C	583°C	577°C

Examples 2—6 cont.

% ultraviolet transmission at					
2250 Å	55%	54%	54%	56%	67%
2500 Å	74	73	67	76	77
2750 Å	82	82	79	85	85
3000 Å	87	87	86	90	90
3250 Å	88	88	88	92	91
3500 Å	88	89	88	92	91

The glass windows from the Examples are sealed directly to the ceramic supports as described above using the solder glass sealing technique without the optional metallic gasket. Similar results are obtained from electronically programming and erasing the memory circuit element. The glass of Example 4 has some minor optical imperfections known as "cords" within the glass.

For the purpose of control, the transmission of a quartz sample and the glass window of Example 1 are compared for similar thicknesses over the entire ultraviolet range. The glass of Example 1 is analyzed to contain 4 parts per million of total iron as Fe_2O_3. For further comparison conventional soda-lime-silica plate glass of like thickness containing the proportions of Fe_2O_3 specified is also provided.

Wavelength in Angstroms	% Transmission			
	Quartz	Example 1	Plate Glass 0.049% Fe_2O_3	Plate Glass 0.066% Fe_2O_3
1900	67	2	<1	<1
2000	74	2	<1	<1
2050	77	27	<1	<1
2100	80	52	<1	<1
2200	86	66	<1	<1
2300	87	69	<1	<1
2500	89	77	<1	<1
2750	91	84	<1	<1
3000	91	88	17	14
3250	92	89	67	68
3500	93	90	84	87

The reading <1% is essentially the baseline reading of the instrument.

The above data indicates that quartz is much more transmissive in the short ultraviolet wavelength and yet the glass windows of invention function quite satisfactorily from the standpoint of ultraviolet erasability in the ROM applications. Furthermore, assemblies prepared from quartz windows have a greater tendency for deterioration and failure upon programming and reprogramming than do the assemblies according to the present invention.

The iron oxide containing plate glass samples do not transmit sufficient ultraviolet for the ROM application.

Example 7

This Example represents a preferred practice of the present invention. A soda-lime-silica glass having the composition and properties set forth below is melted from conventional batch materials by the method of Example 1.

Component	Weight %
SiO_2	68.9
Al_2O_3	6.6
Na_2O	6.0
Li_2O	2.9
CaO	7.2
BaO	5.0
B_2O_3	3.4

The glass has the following properties:

Temperature, where the log of the viscosity in poise is

13.4,=515°C
14.5,=476°C

Coefficient of thermal expansion= 70.7×10^{-7}/°C (0—300°C)

The molten glass prepared above is cast into rectangular bar approximately 32 inches long by 6-1/8 inches wide by 5/8 inches thick. The cross section is then precision ground using a Blanchard grinder with a 120 grit diamond wheel to 6.0 inches wide by 0.590 inches thick. The surfaces of the bar are then polished with a 500 mesh diamond wheel.

The bar is then slowly lowered through a vertical shaft or furnace and the bar is softened by heating to a temperature where the log viscosity of the glass in poise is about 5 to 6. The bottom of the bar is then slowly pulled downward through a set of automatically controlled rollers such that a continuous strip of glass is drawn having a width of 0.50 inches, a thickness of 0.035 inches and a surface roughness of about 4 microinches. The resulting glass strip is then cut into 1/2 inch lengths to form the windows.

The ultraviolet light transmission properties of the windows are:

Wavelength	% Transmission
2250 Å	54%
2500 Å	69
2750 Å	79
3000 Å	86
3250 Å	88
3500 Å	88

These windows are then hermetically sealed in a lead frame assembly using a solder glass seal as shown in Figure 1 but without the optional metal gasket. The ceramic support is an electronic grade of alumina having a coefficient of thermal expansion of $70\times10^{-7}/°C$ (0—300°C).

The hermetic seal is formed from a blend of particulate lead borate solder glass with a particulate beta-eucryptite filler as described in U.S. Patent 3,954,486. The blend comprises 85 parts by weight of solder glass to 15 parts by weight of beta-eucryptite. The solder glass has the composition:

Component	% by Weight
PbO	84.1
B_2O_3	12.3
ZnO	2.7
SiO_2	0.4
BaO	0.5

A sealing paste is prepared by admixing approximately 89 parts of the solder glass blend with 11 parts of a fugitive organic binder. The organic binder comprises 30 parts by weight alphamethyl styrene resin (Dow Resin 276V2—Dow is a registered Trade Mark) and 70 parts of terpineol.

A thin layer of sealing paste is screen printed onto the perimeter of the window. The paste is fired by heating at 400°C for about 14 minutes and then cooled to room temperature. The window has a fused or glazed bead of solder glass around the perimeter corresponding to the area shown in the sealant layer 15 on window 16 as shown in the drawing. Shorter heating period (e.g. 2 to 5 minutes) can be used for this glazing step.

The glazed window is positioned over the cavity of the ceramic support as shown in the drawing and fusion sealed by heating at 400°C for 28 minutes. One window is sealed to the ceramic support by separately applying the solder glass paste to both the window and the ceramic, support, firing and glazing both parts, and then placing the glazed window in position in registry with the glazed area on the ceramic support and fusion sealing by heating to 400°C for 14 minutes. The seal has a coefficient of thermal expansion of about 75 to $77\times10^{-7}/°C$.

The resulting assembly is subjected to thermal cycling tests between −65°C and +200°C according to Military Standard 883, Method 1010, Condition D. Hermeticity of the assembly is measured before and after the thermal cycling by means of fluorocarbon gross leak tests and helium leak detection in accordance with Military Standard 883, Method 1014, Condition A (Helium), Condition C (gross leak Step 1). This test is more stringent than required for the ROM applications. Four of such assemblies are tested and none exceeded the test specification helium leak rate of 1×10^{-8}cc/sec.

Twenty one additional of such assemblies are prepared and tested as above except that the thermal cycling is between −65°C and +150°C. Similar test results are obtained.

One additional sample is prepared as above using a ceramic support having a coefficient of thermal expansion of $50\times10^{-7}/°C$ (0—300°C) and tested as above with thermal cycling between −65°C and +150°C. The sample has a leak rate of about 3×10^{-7}cc/sec which is suitable hermeticity for this application.

The resulting assemblies are suitable for use in ROM devices. The seals are hermetic and quite rugged and durable.

Example 8

The procedures of Example 7 are repeated except that the glass window has a slightly different composition and a coefficient of thermal expansion of $72\times10^{-7}/°C$. The composition of the glass is:

Component	% by Weight
SiO_2	69.3
Al_2O_3	3.7
Na_2O	9.5
CaO	11.5
B_2O_3	6.0

A suitable assembly is obtained.

The procedures of Example 7 are also repeated with a window of the composition set forth below and a suitable assembly is obtained.

Component	% by Weight
SiO_2	72.3
ZrO_2	2.0
Al_2O_3	3.4
MgO	4.0
CaO	9.4
Li_2O	0.5
Na_2O	8.3

Other suitable window glass compositions include:

Component	% by Weight	
SiO_2	68.1	69.3
Al_2O_3	1.8	3.7
CaO	6.7	11.5
Na_2O	12.2	9.5
B_2O_3	11.0	6.0
Coefficient of thermal expansion $\times 10^{-7}/°C$ (0—300°C)	76	71

For the convenience in disclosure, all patents and publications mentioned herein are incorporated by reference.

WHAT WE CLAIM IS:—

1. A semiconductor device assembly comprising a ceramic support having a cavity, an electronically programable memory circuit element positioned in said cavity, said circuit element being responsive to ultraviolet radiation to the extent that any program stored in said element is erased upon exposure to intense ultraviolet radiation, electrical addressing circuitry carried by said support and connected to said circuit element, and an ultraviolet radiation transmissive window sealed in a position overlaying said cavity; said window being a homogeneous, soda-lime-silica glass having an ultraviolet transmission of at least about 30% and 2500 Å and comprising:

Component	Weight %
SiO_2	65 to 75
CaO	5 to 15
Na_2O	5 to 15

2. A semiconductor device assembly as claimed in claim 1, where said glass further contains up to about 20% of glass making oxides in the following proportions: 0—10% Al_2O_3, 0—12% B_2O_3, 0—10% MgO, 0—10% BaO, 0—10% P_2O_5, 0—10% ZnO, 0—10% Li_2O, and 0—5% ZrO_2.

3. A semiconductor device assembly as claimed in claim 1 or 2, in which said glass has a coefficient of thermal expansion in the range of 65 to $90 \times 10^{-7}/°C$ (0—300°C).

4. A semiconductor device assembly as claimed in any one of the preceding claims, in which said ceramic support is alumina.

5. A semiconductor device assembly as claimed in any one of the preceding claims, in which said window transmits at least about 50% at 2500 Å.

6. A semiconductor device assembly of claim 1, further including an apertured metal gasket secured to said ceramic support, said metal gasket having an aperture therein positioned in registry with said cavity, wherein said window is sealed to said metal gasket in a position overlaying said cavity.

7. A semiconductor device assembly as claimed in any one of claims 1 to 5, in which said window is hermetically sealed directly to said ceramic support with a solder glass seal.

8. A semiconductor device assembly as claimed in any one of the preceding claims, wherein said window is sealed with an epoxy resin seal.

9. A semiconductor device assembly substantially as hereinbefore described with reference to and as illustrated in either of the figures of the accompanying drawings.

10. A semiconductor device assembly substantially as hereinbefore described in any one of the foregoing examples.

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Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1978
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.

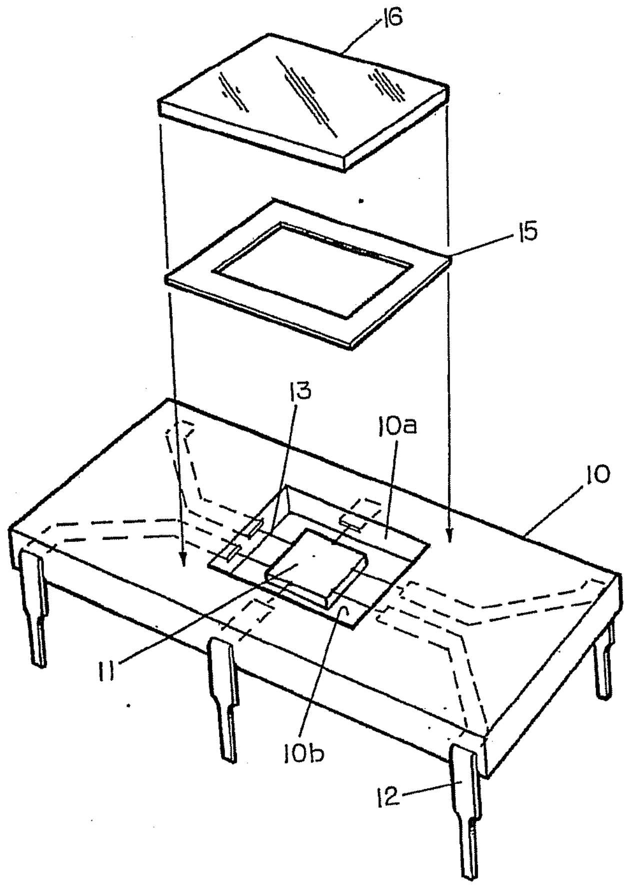

FIG. 1

1503136 COMPLETE SPECIFICATION

2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*

Sheet 2

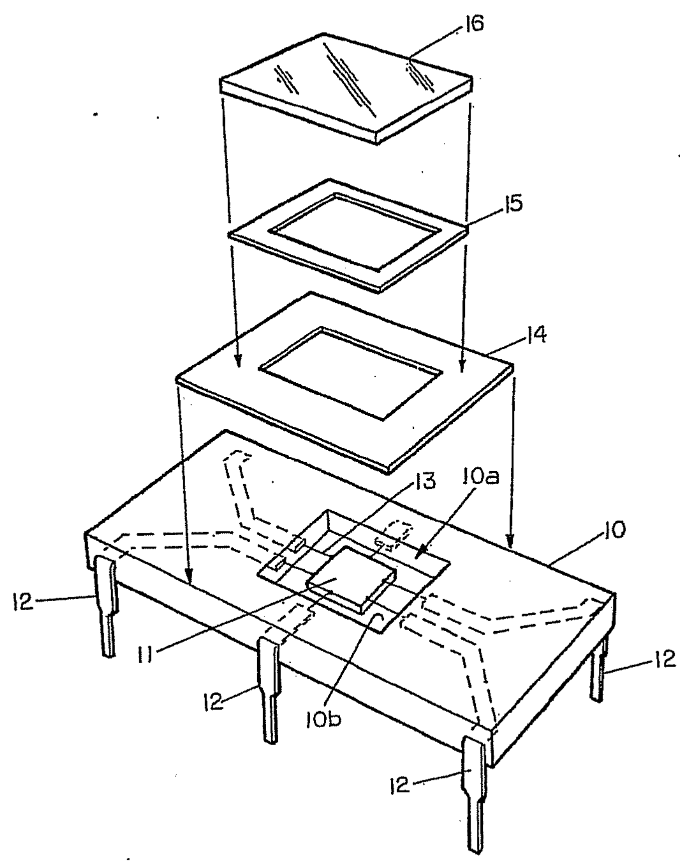

FIG. 2